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THE EXAMINATION OF BUILDING 65 AT LAKE CITY ARMY AMMUNITION PLANT FOR USE AS A PRODUCTION FACILITY FOR SCAMP B

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FOREWORD

This report was accomplished as part of the Safety Engineering Graduate Engineering Program conducted jointly by the USAMC Intern Training Center and Texas A&M University. As such, the ideas, concepts and results herein presented are those of the author and do not necessarily reflect approval or acceptance by the Department of the Army.

This report has been reviewed and is approved for release. For further information on this project contact Dr. George D. C. Chiang, Intern Training Center, Red River Army Depot, Texarkana, Texas 75501.

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This report is an examination of Building 65 at Lake City Army Ammunition Plant for use as a production facility for SCAMP B. The SCAMP system is described in detail and the objectives and benefits of SCAMP are outlined. Design considerations that are of prime importance are discussed and the concepts of quantity distance are explained. Allowable quantities of explosives are determined for selected cartridges and space requirements are examined with recommendations made concerning building additions.

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REPORT

THE EXAMINATION OF BUILDING 65
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FOR USE AS A PRODUCTION FACILITY FOR SCAMP B

by

Philip R. Jose

Accomplished as Part of the
AMC Safety Engineering Graduate Program
USAMC Intern Training Center

and

Presented in Partial Fulfillment of the Requirements of the
Degree of Master of Engineering
Texas A&M University
November 1975

ABSTRACT

Research Performed by Philip R. Jose

Under the Supervision of Dr. R. B. Misra

This report is an examination of Building 65 at Lake City Army Ammunition Plant for use as a production facility for SCAMP B. The SCAMP system is described in detail and the objectives and benefits of SCAMP are outlined. Design considerations that are of prime importance are discussed and the concepts of quantity distance are explained. Allowable quantities of explosives are determined for selected cartridges and space requirements are examined with recommendations made concerning additional construction. Conclusions are drawn and recommendations are made as to areas of further research.

ACKNOWLEDGEMENTS

I would like to extend my thanks to Dr. R. B. Misra, my committee chairman, for his patience and assistance in the preparation of this report. For serving as members of my committee, I wish to thank Dr. S. B. Childs and Dr. J. W. Foster . My gratitude is extended to Mr. John Spencer, Mr. John Jacobi, and the personnel at Lake City for their assistance. My thanks also, to my wife Julie, for her encouragement throughout the development of this report.

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The ideas, concepts, and results herein presented are those of the author and do not necessarily reflect approval or acceptance by the Department of the Army.

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CHAPTER I

INTRODUCTION

The Vietnam conflict brought to light the need for new methods of producing ammunition. The heavy use of rapid firing air to ground weaponry bore an unending demand on our production for 20mm and 30mm small caliber ammunition. These new sophisticated weapons were capable of firing as many as 6,000 rounds per minute, and the outdated machinery being used to produce ammunition was not able to meet such rigorous demands. In fact, if it were not for our large stockpiles of ammunition that were available during the Vietnam War, a serious shortage would have occurred.

With the realization that a serious gap could occur if the need for prolonged supply would again arise, several studies were initiated to determine methods and means of improving and modernizing cartridge production. The initial search for technology to modernize small caliber ammunition production was initiated at Frankford Arsenal in mid 1968. The program was labled SCAMP - an acronym for "Small Caliber Ammunition Modernization Program".

SCAMP is divided by cartridge size into two areas. The first is module A, designed to produce 5.56 mm and 7.62 mm ammunition and second module B, designed to produce .50 caliber, 20 mm and 30 mm ammunition.

With the prototypes of Module B now being brought into operation, the Army is in the process of evaluating the redesign of existing structures now being used for ammunition production. One of the first locations being considered for SCAMP B installation is building 65 at Lake City Army Ammunition Plant in Independence, Missouri. The basis for this report is to explore the possibilities of this redesign, to evaluate possible configurations for Module B within the existing structure, and to determine whether or not additional construction is needed in order to accomplish the desired output rates while meeting applicable safety standards.

The SCAMP B concept is explained in chapter 2 of this report. It outlines the objectives which SCAMP will try to achieve as well as the benefits to be derived from the system. This chapter will also give the reader an understanding of SCAMP B through an explanation of the basic functions of the submodules which make up the system.

Important design considerations for explosives facilities as related to SCAMP B are covered in chapter 3. Among the considerations discussed are the class system for hazardous explosives and the concepts and requirements for quantity distance. The latter is a primary consideration in this report.

In chapter 4 allowable quantities of explosives are discussed along with the adaptability of two production lines within Building 65. Space requirements are examined

with respect to submodule placement and suggestions are made concerning additions to the building.

In chapter 5 recommendations are made and conclusions are drawn on the author's investigation of the system and the analysis contained within this report. Limitations of the analysis are covered and recommendations are made as to areas needing further work.

CHAPTER II

THE SCAMP B CONCEPT

OBJECTIVES

In order to establish a means of evaluating various concepts for SCAMP, a series of objectives to be achieved and benefits to be derived were established. They are as follows : (14) *

1. To achieve a substantial reduction in inventory on-hand and requirements for storage space through decreased production lead time and increased rates.
2. To reduce cost of manufacturing by reducing man-hours required. Reducing maintenance cost, improving tool life and increasing machine efficiency.
3. To improve quality of product and reduce scrap through better controls, better processes and continuous inspections.
4. To reduce firing test costs, time, quantities fired, and inventory held pending completion of tests by use of automated on-line testing and improved quality of product.

* Numbers in brackets refer to numbered references in the bibliography.

5. To improve ability to meet changing mobilization and peacetime requirements through versatility, i.e., conversion from one to another caliber; ability to handle a variety of metals; conversion within defined limits to manufacturing new generation cartridges; and most important of all, replacement of an obsolete base.
6. To improve environmental conditions at the worksite and in the community through better pollution control, application of human engineering, and reduction in working hazards.

In order to achieve these objectives the following operational criteria were established:

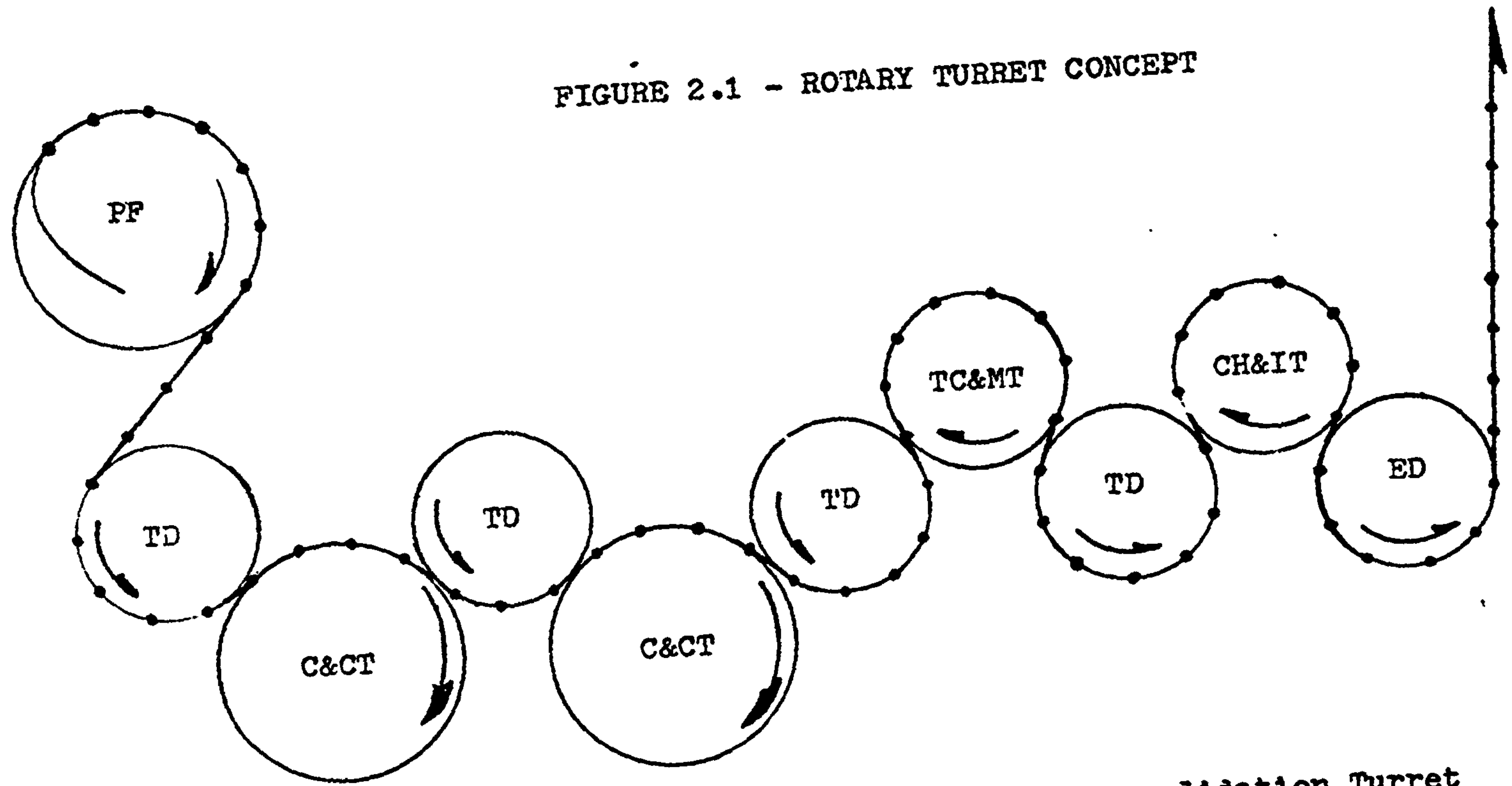
1. Minimum design operating speed of 600 rounds per minute.
2. Transportation of components through all manufacturing and packing operations in continuous motion in a captive work oriented position.
3. Automation of in-process inspection and identification of defects as early as possible with rejection of defective materials.
4. Incorporation in design features necessary for a successful preventative maintenance program.
5. Operation must be economical when running at less than design speed.

6. Provision for acquisition of quality control and production management data through logic devices and computers.
7. Incorporation of the modular concept for failure-prone components and perishable tooling, allowing for quick replacement of these components by minimum skilled operating personnel.

After a long careful study of the available methods of conversion, a new system utilizing rotary turrets similar to that found in the pharmaceutical industry was used as the basis for modernization. A somewhat simplified example of this concept is shown in figure 2.1 .

Although the design production rate is 600 pieces per minute (ppm), a more realistic rate during daily operation will be approximately 300 ppm. However, even this slower rate will exceed by more than 4 times the current production rate of 40 to 70 ppm. Production is now based on a batch method of material handling, which is slow and inefficient. The SCAMP system utilizing a continuous production flow technique will afford greater efficiency at higher production rates and at lower costs primarily due to a drastic reduction in labor requirements. (15)

FIGURE 2.1 - ROTARY TURRET CONCEPT



PF - Projectile Feeder

TD - Transfer Disc

ED - Eject Disc

C&CT - Charge and Consolidation Turret

CH&IT - Charge Height and Inspection Turret

TC&MT - Thread Clean and Mill Turret

COMPANIES INVOLVED IN DEVELOPMENT

Through my reading and discussion with personnel related with SCAMP, I have found that it is generally accepted that the operational responsibility for SCAMP Module B will be assigned to Remington Arms Company, Inc. at Lake City. Their responsibilities should include planning, preparation of engineering proposals, and execution of engineering proposals approved by the Government for plant expansion projects, short range improvement projects, and plant upgrading projects.

The first phase development on the automatic cartridge assembly prototype will be handled by the Gulf and Western Corporation. This includes the design and fabrication of the basic machinery necessary to perform assembly operations at the design rate of 600 ppm. H. P. White Laboratories has the first phase of a prototype development contract for HEI, High Explosive Incendiary, charging which includes the design and fabrication of the basic machinery. The Link Pack contract was awarded to the Design and Development Company for a prototype M14 type linked cartridge and M548 container system. Ameron Corporation is working with the steel case development. An extensive preliminary Facility Systems Analysis for Module B has been performed by Paul R. Zirkel of Honeywell Incorporated. An ammunition production base restructure study for SCAMP was performed in 1973 at Frankford Arsenal.

SUBMODULE CONCEPT

In order to achieve the objectives listed, a concept utilizing submodules for each of the main phases of production was established. The submodule concept has proven to be an effective method of production for Module A and will be applied to Module B.

A submodule is defined as the equipment necessary in the production of major components, such as the cartridge case. Module B is an integrated series of submodules with a common production rate and capacity, coupled together by a transfer and quality control system. In all there are thirteen submodules which make up the entire system for Module B. The following description of each of the submodules indicates what submodules are involved. A process flow diagram, Figure 2.2, is used to illustrate the material and information flow between each submodule. (15)

<u>CASE MANUFACTURE</u> - This submodule will manufacture the M103A1 steel cartridge as illustrated in Figure 2.3 . The case will be made through a number of draw out processes starting with flat discs that will be cut from sheet stock steel. A modified rotary system using a "Swash-Toggle" concept will be considered to develop the larger forces required for forming the steel case. A design requirement of 600 ppm will be used for this submodule.

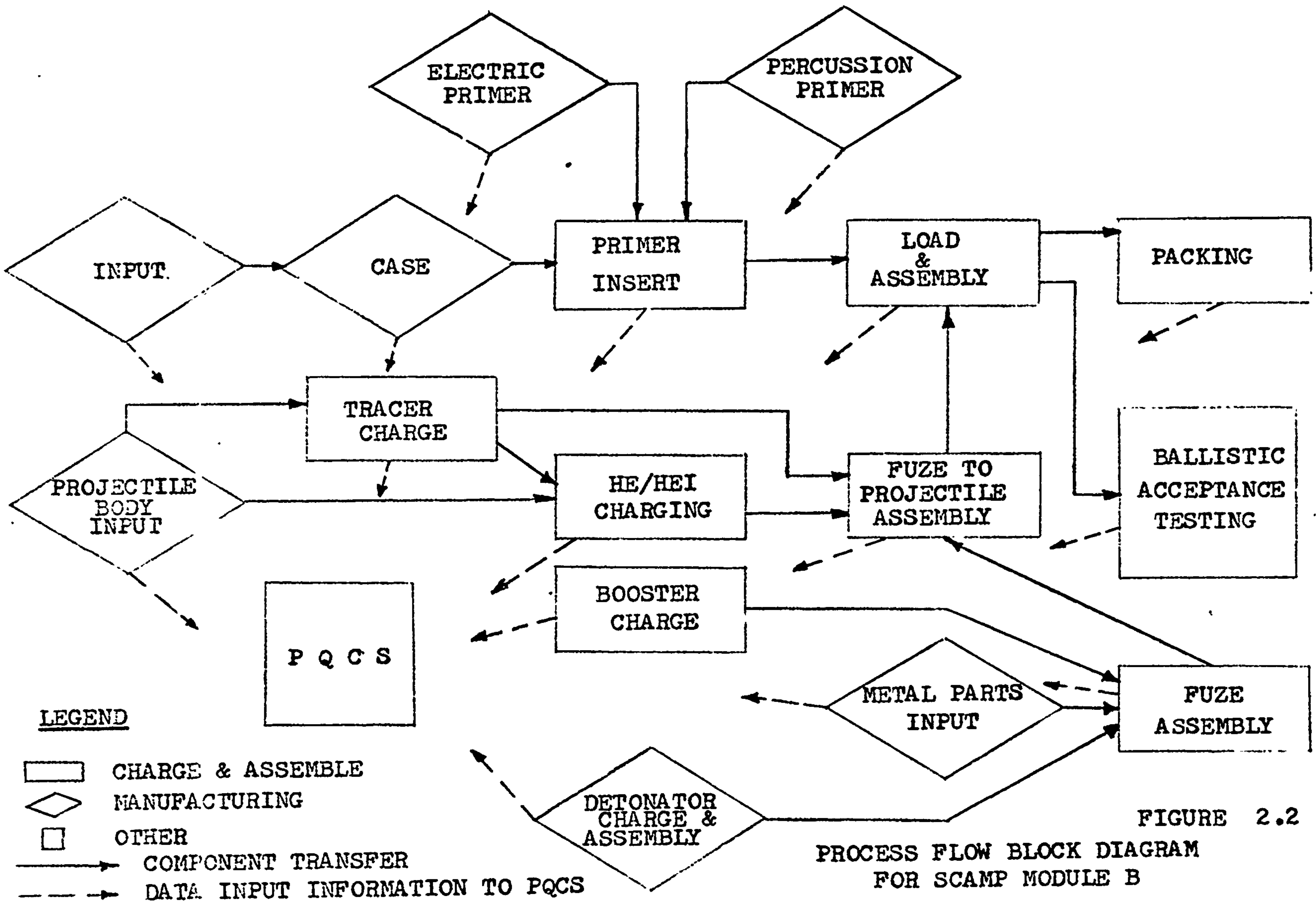
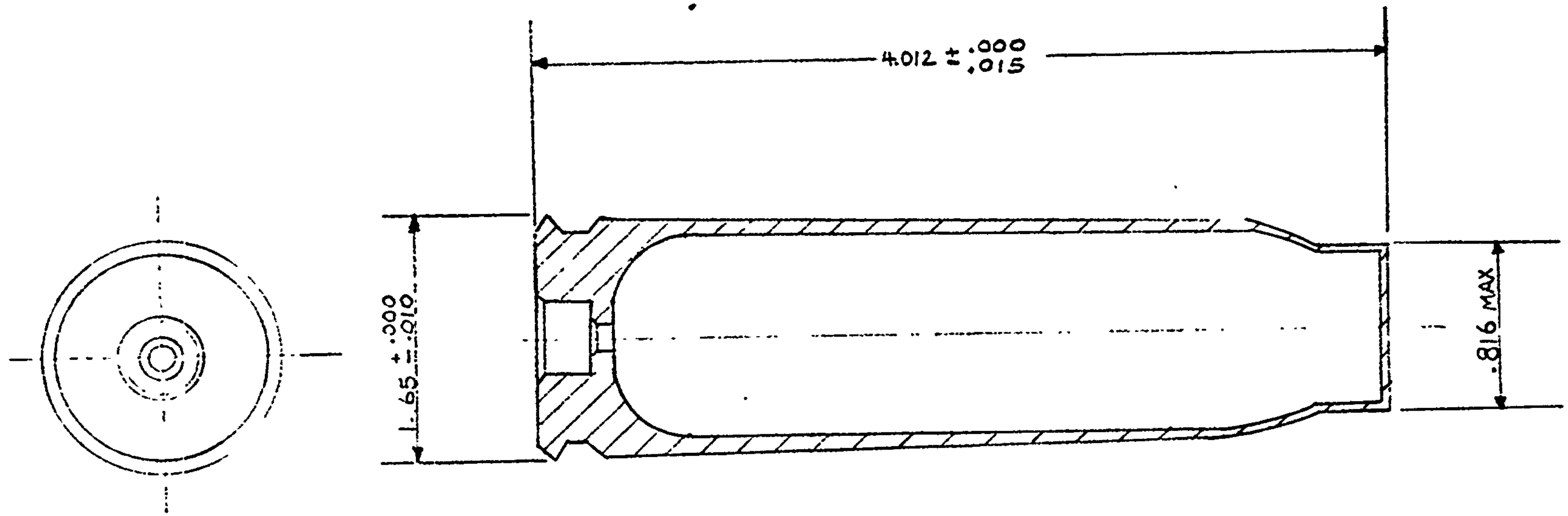


FIGURE 2.2

PROCESS FLOW BLOCK DIAGRAM FOR SCAMP MODULE B



CASE, CARTRIDGE, 20mm, M103A1

FIGURE 2.3

* not drawn to scale

PRIMER MANUFACTURE - This submodule is designed for manufacturing percussion and electric primers at varying rates up to 1200 ppm. The submodules are compact, self contained and fully automated machine systems incorporating a 100 percent failsafe inspection system for all critical parameters. The equipment developed for primer manufacture will be universal in nature such that conversion from one primer requirement to another will be accomplished through the use of interchangeable tooling and feed systems.

PRIMER INSERT - This submodule will be designed to accommodate electric or percussion primers as required, along with various cartridge sizes. The process will be accomplished at a design rate of 600 ppm and will incorporate a 100 percent fail-safe inspection system to insure that all critical parameters comply with appropriate specifications. The primed cases will then be discharged to a transfer system for delivery to the load and assemble submodule.

LOAD and ASSEMBLE - This is a self-contained, universal and fully automated submodule capable of loading and assembling cartridges at variable rates up to 600 ppm. Remote controls are included to

provide maximum personnel safety and minimize the number of operating personnel. The machine receives primed cases and projectiles in a captive and oriented manner, receives and dispenses propellant and performs other operations leading to discharge of assembled and loaded cartridges to a transfer system for delivery to the packing submodule. The load and assemble submodule also includes a 100 percent fail-safe inspection system.

<u>TRACER CHARGING</u> - This submodule receives and charges at a rate of 600 ppm. The machine has devices for accepting and monitoring the applicable trace mixes and provides for interchangeable tooling and feed systems for conversion to different projectile sizes. Remote control facilities are included to insure maximum personnel safety. The tracer charged projectiles discharge to a transfer system for delivery to the HE/HEI, High Explosive/ High Explosive Icendiary, charge submodule.

<u>HE/HEI CHARGING</u> - Producing at the rate of 600 ppm this self contained, fully automated submodule will be remotely controlled to reduce operating personnel and insure safety. A 100 percent fail-safe inspection system will monitor all critical parameters to insure compliance with quality standards.

The HE/HEI charged projectiles are discharged to a transfer system for delivery to the fuze-to-projectile assembly submodule.

DETONATOR CHARGE and ASSEMBLY - The explosive material used in charging at this submodule is lead azide, and RDX (Cyclonite) and is extremely hazardous. Therefore remote control and other devices will be used to insure full and complete protection of all operating personnel. Fail-safe inspection will also be incorporated into this submodule.

BOOSTER CHARGE ASSEMBLY - This submodule will charge and assemble fuze boosters at a rate of 600 ppm. It will incorporate remote control for the protection of operating personnel and fail-safe inspection will take place to verify all critical parameters. Charged and assembled fuze booster holders will then be delivered to the fuze assembly submodule.

FUZE ASSEMBLY- This submodule assembles charged rotors and booster holders with fuze assembly of 600 ppm, and is fully automated and self contained. From here the fuze assemblies are transfered to the fuze-to-projectile assembly submodule.

FUZE-TO-PROJECTILE ASSEMBLY - This machine accepts and orients charged fuzes and applies the proper thread sealants. It is a self contained and fully automated submodule capable of assembling charged point detonating fuzes to HE/HEI charged projectile bodies at rates up to 600 ppm. The equipment uses 100 percent fail-safe inspection and remote control facilities are provided to insure personnel safety. The assembled fuze and charged projectile bodies are discharged to a transfer system for delivery to the load and assemble submodule.

PACKAGING - This submodule accepts assembled cartridges and processes the components in a captive oriented manner from linking through palletizing and banding operations. It links at variable rates up to 600 ppm and assembles cartridges into prescribed belt lengths with predetermined ratios of HE/HEI and tracer cartridges and packages the belted cartridges in M548 containers.

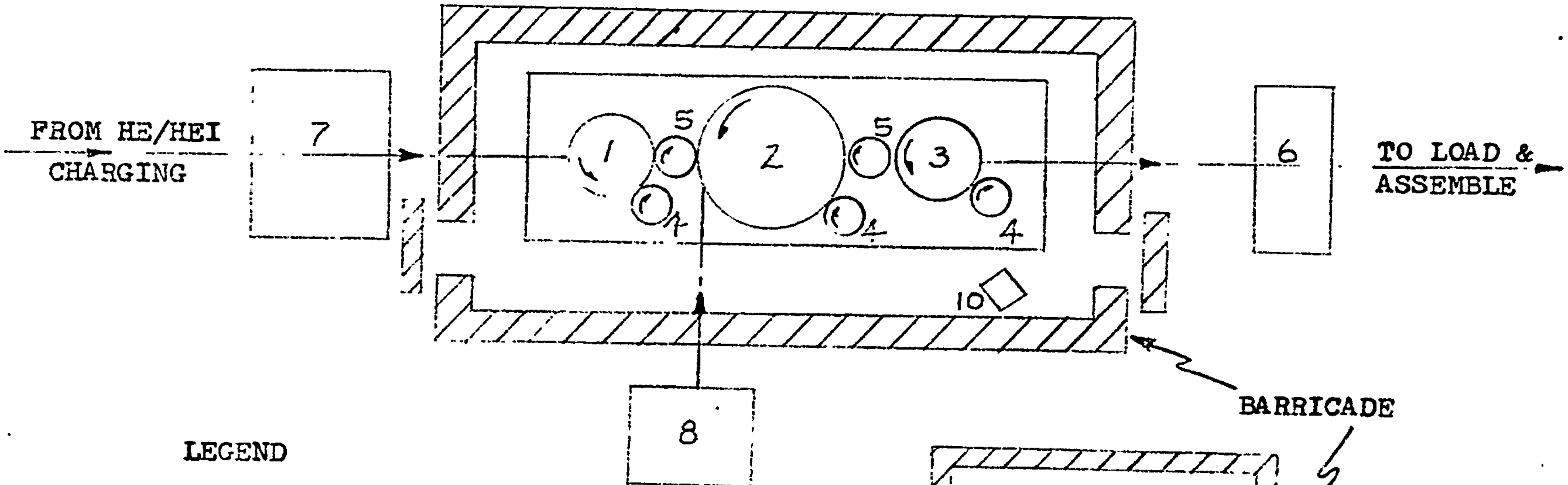
BALLISTIC ACCEPTANCE TESTING - The ballistic acceptance will perform all those tests now done by the present range but in an automatic fashion employing a computer. The automatic equipment will reduce the time between actual testing and the reporting of the test results. The time reduction will avoid problems of storage of ammunition to await test

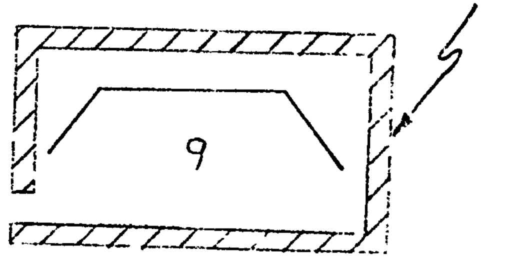
results and will also permit a faster process correction to adjust the propellant charge in the load and assemble module should the ammunition fail the prescribed tests.

PROCESS QUALITY CONTROL SYSTEM (PQCS) - This master quality assurance computer will monitor the entire production process continuously analyzing the inspection data. It will predict potential trouble by determining if any adverse trends are developing and give indications of preventive maintenance. This system will greatly decrease the amount of down time and improve overall production efficiency. The use of the computers storage bank will enable management to make accurate decisions when scheduling production, maintaining inventory control and ordering raw materials.

To better understand the workings of the submodule concept, a representative example of how one of the submodules might be laid out is shown in figure 2.4 . The submodule represented is the Fuze-to-Projectile Assembly.

As illustrated in figure 2.4, the main components of the submodule are located within a barricaded area with no personnel present within the barricade. The direction of material is indicated by arrows. The projectiles are brought in from the HE/HEI charging area and accumulated in an automatic feeder. The first step in this submodule is the





LEGEND

1. Sealant applicator, sealant check
2. Fuze-to-projectile assembly
3. Height & gap check
4. Reject stations
5. Transfer stations
6. Inspection for excessive sealant, loose fuze covers, orientation of fuze to projectile
7. Projectile feeder
8. Fuze orienter with one operator to load
9. Main operation console
10. TV camera

FIGURE 2.4

FUZE-TO-PROJECTILE ASSEMBLY

application of a sealant to the threads and a sealant check. Once this is accomplished the oriented fuzes are fed in and assembled to the projectiles. Height and gap openings between the fuze and the projectile are then checked. A continuous inspection is under way during all phases of assembly and reject stations gather the out of spec cartridges. A final inspection is made outside the barricaded area for excessive sealant, loose fuze covers, and orientation of the fuze to the projectile. Closed circuit television also monitors the operations and viewing screens are provided for each of the operators. The barricaded control room contains the main operation console with monitoring and process controls.

MANPOWER REQUIREMENTS

The original manpower requirements were developed on the basis of two modules operating on a 2-5-8 shift basis, that is two shifts operating eight hours per day five days per week. However recent reports suggest the strong possibility of a six day work week instead of five.

The total number of personnel needed to run the complete two module system is projected to be 382. Personnel required for the direct labor of operating the machines will number 154, an additional 58 supporting personnel will be necessary with 170 indirectly related personnel rounding out the 382 figure. The automatic component transfer and material handling systems will not need constant supervision.

Any attention to be given these systems will be minor, other than periodic maintenance, which can easily be handled by the personnel operating the submodules. It should be noted that the ballistic testing and Process Quality Control System personnel will handle both production lines therefore reducing manpower requirements. Table 2.1 shows a breakdown of the labor force as related to the submodules.

TABLE 2.1

MANPOWER REQUIREMENTS

SUBMODULE	MEN PER SUBMODULE
Case Manufacture	7
Primer Insert	8
Load and Assemble	3
HE/HEI Charging	5
Fuze to Projectile Assembly	3
Packaging	13
Detonator Charge and Assembly	7
Tracer Charging	2
Fuze Assembly	1
Primer Manufacture	21
Booster Charge and Assembly	5
Component Transfer/Material Handling	0
Ballistics Testing	3
PQSC	1
Total	79

Manufacturing Technology Directorate Report, November 1973, p. 4.2

CHAPTER III

DESIGN CONSIDERATIONS FOR EXPLOSIVES FACILITIES AS RELATED TO SCAMP B

SPECIAL CONSIDERATIONS FOR INITIATING EXPLOSIVES

The initiating explosives lead azide and RDX (cyclonite) will be present in bulk quantities in the detonator charge and assembly submodule. Special precautions are necessary due to the sensitivity of these explosives. They are sensitive to friction, heat and impact, and will detonate without burning when involved in a fire.

Whenever these materials are worked with or stored, the quantities should be limited to the smallest practical amount. For long periods of storage, they should be kept wet with water or a water-alcohol mixture. A wet type dust collection system should be used in areas where initiating explosives are worked with. The sensitivity of these materials is increased by many foreign materials and it is therefore mandatory that a high degree of cleanliness be maintained. All rooms in which these explosives are to be handled must be designed to be completely free from static electricity or flooring must be made of conductive material. It would be desirable for both of these conditions to be met in order

to achieve the highest degree of safety. The walls of the rooms should be constructed of a waterproof material with a hard gloss finish and should be washed often with a neutralizing solution to prevent explosive dust buildup on the surface.

THE CLASS SYSTEM FOR HAZARDOUS EXPLOSIVES

The Army has divided hazardous explosive material into seven classes, severity of hazard increasing as numbers increase. Class 1 is considered to be ammunition that presents a fire hazard but no blast or fragmentation hazard beyond the fire hazard clearance specified for high-risk materials. Class 2 explosives are defined to be propellants and single-base, single-perforated rifle propellant. Class 3 materials are fuzes and artillery primers, and should be handled in such a manner as not to strike against each other. In the event of an explosion involving Class 3 material the fragments generated are considered to be light and would not endanger areas beyond 300 feet. Classes 4 and 5 are considered to be ammunition that presents little threat of fire unless deterioration has occurred. If a single item in a stack of Class 6 ammunition detonates, or if the stack is exposed to fire, the entire stack of explosives will detonate as a mass. For this reason Class 6 material should not be stored in large quantities without taking precautions to prevent propagation to nearby stacks of explosives. Class 7 items are hazardous explosives of the highest order and if

involved in a fire will mass detonate.

QUANTITY DISTANCE REQUIREMENTS

Quantity distance specifications refer to the limiting minimum distances allowable between any two areas, such as buildings, based on the quantity of explosives these areas contain.(10) The maximum amount of explosives that may be located in any one area is regulated by the distance between the hazard and other areas that could be damaged as a result of an explosion of the hazardous material. Two other factors that could either shorten or lengthen this distance are the type of structure, construction, occupancy, etc. and whether or not barricading, either natural or man-made, exists.

Tables in Chapter 17 of AMCR 385-100 are available for determining the minimum allowable distances between explosive hazards and specified building and area types. It should be emphasized that the distances given in the tables are the minimum required for safe operation. The distances should never be shorter than those listed and if at all possible greater when space permits.

Quantity distance requirements can be expected to provide protection to buildings so that propagation of explosions due to blast effects are minimized but it does not provide protection against explosive propagation due to hazardous fragments. A hazardous fragment being defined as one having an impact energy of 58 foot-pounds or more.

Inhabited building distance as defined in AMCR 385-100 is the minimum permissible distance between an inhabited building and an ammunition or explosives location. An inhabited building being defined as; "A building or structure other than operating buildings, magazines and auxiliary buildings occupied in whole or in part as a habitation for human beings, or where people are accustomed to assemble, both within and outside of Government establishments. Land outside of the boundaries of AMC establishments shall be considered as possible sites for inhabited buildings." Because of the possible harm to human life in the event of an explosion, nearby inhabited buildings are of primary concern when designing an explosives facility. Inhabited building distances are also used between adjacent operating lines, explosives locations and other exposures within an establishment.

Public railway quantity distances for class 7 explosives are calculated as 60 percent of the inhabited building distance and can be found in table 7-11 of AMCR 385-100 along with inhabited building quantity distances. The reasons for the allowable decrease in distance is the greater resistance of railroad cars to blast effects as compared with buildings, and that the percentage of time the cars are exposed to the hazard is considerably less than buildings which are stationary and subject to constant risk. For materials other than class 7, the required quantity distances for public railways are equal to the inhabited building distances.

Public highway quantity distances are identical to public railway distances.

Intraline distance is the minimum permitted distance between any two buildings within one operating line.(17) This distance is also used for certain areas and buildings even though actual line operations are not involved. The only exceptions are service facilities which serve a particular operating explosives facility. In this instance the intraline distance requirement does not have to be met but may never be less than 100 feet from the building which it serves. However, it must comply with intraline distance requirements for all other explosives facilities in the area.

The maximum quantity of explosives permissible in each existing building is defined by DOD 4145.26M: "Separation distances for determining the maximum allowable quantity of explosives shall be measured from the outside of the nearest wall, side or back of a structure, controlling room or controlling cubicle to the outside of the nearest wall, side or back of another structure, room or cubicle."

BARRICADING

Properly constructed artificial or natural barricades are an effective method of protecting nearby structures from damage due to explosion. They also are an effective means of reducing the allowable quantity distance requirements for buildings housing explosives. However, such barricades are generally considered to be ineffective for

reducing distances required for fire hazard materials such as class 2 propellant and missile producing ammunition such as in classes 3, 4, 5 and 6. Barricading is considered most effective for items having mass detonating characteristics.

A barricade is considered effective when properly constructed and when a line drawn from the top of any side-wall of the building containing the explosives to all the parts of the location to be protected will pass through the intervening barricade. (5) The barricade must be separated from each of the buildings and may be located adjacent to either, although it is preferable to locate it near the building that is being protected. The toe of the barricade must be no further than 40 feet from the structure and is recommended to be as near as possible to the minimum distance of 4 feet.

CHAPTER IV

PROPOSALS OF PRODUCTION RATES

AND

BUILDING LAYOUT CONSIDERATIONS

INTRODUCTION

Building 65 at Lake City is being considered for housing two production lines consisting of the following submodules; Tracer Charging, HE/HEI Charging, Fuze-To-Projectile Assemble, and Link Packing. The System Integration Report for Preparation/Layout Planning for Module B states that "It is the objective of the contractor to direct all reasonable effort to adapt the submodules to the existing building configuration." Therefore the possibility of operating the required submodules within the existing structure will be explored.

In this chapter allowable quantities of explosives for four cartridge types will be examined and recommendations will be made as to whether or not the proposed production methods will or will not violate existing quantity distance requirements. Space requirements will also be looked at in order to determine the most efficient means of arranging the submodules. In addition, some ideas concerning new construction and placement of expanded facilities within building 65 will be discussed.

ALLOWABLE QUANTITIES OF EXPLOSIVES IN EACH SUBMODULE

Four types of cartridges were considered as representitive of the majority of the ammunition to be produced in Building 65. They were examined for the purpose of determining whether or not they could be produced at the design production rates and meet the requirements for quantity distance. The designations of the cartridges considered are listed in Table 4.1 along with the grains of explosives in each projectile, the number of projectiles that can be charged with one pound of explosives, and the total pounds of explosives that are in 1000 projectiles of that particular piece of ammunition.

Table 4.2 lists the types of primer components and fuzes that are used in the four cartridges considered. Listings are given in the same manner as in Table 4.1, grains each, pieces per pound, and pounds per 1000 pieces.

The information from Tables 4.1 and 4.2 is used in making up a comprehensive Table, 4.3, that gives in addition to the explosives that are present in the form of projectile charges, primers, and fuzes, the pounds of explosives present in 1000 completed rounds of the designated cartridge. The additional explosive material that makes up the total amount in the completed round is in the shell casing in the form of propellant. This is also listed in the table. For the purpose of maximizing the safety factor the electric primer

TABLE 4.1

EXPLOSIVE QUANITIIES IN PROJECTILES

COMPONENTS & OPERATIONS	GRAINS EACH	PIECES PER POUND	POUNDS PER 1000
M56A3 HEI			
1st & 2nd Charge	150.00	46.6667	21.249
3rd Charge	26.00	269.2308	3.714
Total	176.00	315.8975	25.143
M53 API			
1st Charge (IM 136)	25.00	280.0000	3.571
2nd Charge (IM 68)	30.00	233.3333	4.286
3rd Charge (IM 68)	21.00	333.3333	3.000
Total	76.00	846.6666	10.857
M246 HEIT-SD			
Charge Tracer Cavity:			
1st Charge (Trace Mix LC-5B)	16.00	437.5000	2.286
2nd Charge (Trace Mix LC-5B)	11.00	636.3636	1.571
3rd Charge (Ign. Mix LC-#2)	5.00	1400.0000	.714
4th Charge (Ign. Mix 1-136)	5.00	1400.0000	.714
Charge HEI Cavity:			
WC-870	12.00	583.3333	1.714
LCA#1	50.00	140.0000	7.143
LCA#1	34.00	205.8824	4.857
LCA#1	34.00	205.8824	4.857
Total	167.00	5008.9617	23.856
M242 HEIT			
Charge Tracer Cavity:			
1st Charge (Trace Mix R-403)	12.00	583.3333	1.714
2nd Charge (Trace Mix R-403)	15.00	466.6667	2.143
3rd Charge (Sub I Mix 1-280)	4.00	1750.0000	.571
4th Charge (Ign. Mix 1-136)	5.00	1400.0000	.714
Charge HEI Cavity:			
1st Charge LAC #1	75.00	93.3333	10.714
2nd Charge LAC #1	37.50	186.6667	5.375
3rd Charge LAC #1	34.00	205.8824	4.857
Total	182.5	4685.8824	26.070

TABLE 4.2

EXPLOSIVE QUANTITIES
IN
PRIMER COMPONENTS AND FUZES

PRIMER COMPONENTS

COMPONENTS & OPERATIONS	GRAINS EACH	PIECES PER POUND	POUNDS PER 1000
Electric (M52A3B1) Pellet	2.58	2456.1404	.047
Percussion (36A1E1) Pellet	2.20	3181.8182	.314

FUZE

COMPONENTS & OPERATIONS	GRAINS EACH	PIECES PER POUND	POUNDS PER 1000
Booster			
1st Charge	7.78	899.7429	1.111
2nd Charge	6.80	1029.4118	.971
3rd Charge	7.02	997.1510	1.003
Total	21.60	2926.3057	3.085
Detonator M57E1 (Al. Cup)			
1st Charge	.386	18134.7150	.005
2nd & 3rd Charge	1.997	17259.1753	.285
Total	2.383	35393.8903	.290

TABLE 4.3

TOTAL EXPLOSIVE QUANTITIES IN COMPLETED CARTRIDGES *

CARTRIDGE TYPE	PROJECTILE CHGE.	PRIMER	FUZE	PROPELLENT	COMPLETED ROUND
M56A3 HEI	25.143	.407	3.375	61.675	90.6
M53 API	10.857	.407	3.375	73.861	88.5
M246 HEIT-SD	23.856	.407	3.375	63.262	90.9
M242 HEIT	26.070	.407	3.375	60.184	90.0

* All explosive quantities are listed in pounds per 1000 rounds

was considered to be used in all cases,as the explosive quantity present was slightly higher than that of the percussion primer.

In determining the amount of explosives allowable in each submodule,i.e.;the maximum pieces of ammunition in any one area, the actual numbers shall be dependent upon the distances that exist between Building 65 and surrounding structures. It is assumed that each submodule will be designed so that an explosion in any one area will not propagate to nearby submodules. This will be accomplished by effective barrier design, proper placement and spacing of the submodules within the building and by keeping the quantities of explosives in a single submodule within acceptable recommended limits.

When determining the allowable production rates and accumulation of explosives within a submodule the governing safety manual AMCR 385-100 states in paragraph 17-8a on page 17-4 that "When the total quantity is so subdivided that an incident involving any one of the subdivisions will not produce simultaneous initiation of others, the net weight of the mass-detonating explosives in the largest subdivision shall apply." Therefore the existing quantity distances will determine the maximum amount of explosives allowable in one submodule and not the total quantity for the entire building.

In so much as the majority of the explosives that will be used in Building 65 will be Class 7, Mr. John Jacobi, Chief Engineer at Lake City has suggested that for the

purpose of this report, all explosives to be used may be considered Class 7. This will provide yet another safety factor in that the quantity distances caloulated will be of the highest order and the allowable quantities of explosives determined will be considered conservative due to the fact that some of the explosives will actually be of a lower class. This suggestion will be followed and is considered by the author to be a reasonable approach, as similar suggestions are made in applicable Army documents.

According to Lake City Engineers the production methods that will initially be used will not include the proposed conveyer type transfer system for movement of cartridges between submodules. Instead they will use a buggy system similar to that presently in operation in Module A. The buggies to be used will hold approximately 1,200 rounds of 20mm or 30mm ammunition. The present plan is to make 20 minute production runs, allowing the products of each submodule to be collected in the buggy and remain in the submodule until the end of the run. At that time the loaded buggies will be brought through the center corridor to the submodule which is next in the production line.

Regulations state that a supply of material capable of maintaining production for 1 hour or 3 twenty-minute runs must be available at all times. Therefore the bays containing hazardous supply materials will have these necessary amounts in them, and will be the areas of the highest concentration of explosives.

During production the loaded buggies will be moved directly to the next submodule in the production line for continued processing. However, at some stage a backup may occur and the empty bays within the loading wing will most likely be used for storing the excess marerial. This will be considered acceptable as long as the quantities stored do not exceed the recommended maximums for one bay.

Table 4.4 shows the maximum amount of explosives that will be present in any submodule for the four cartridge types being considered. Figure 4.1 shows the distances to nearby roads, railroads, and buildings which are to be considered when determining allowable quantities of explosives in Building 65. As can be seen the shortest inhabited building distance is 670 feet. This is building 143, a testing laboratory. The two public highway/railway distances to be considered are 4,700 feet and 5,450 feet.

The maximum amount of explosives from Table 4.4, 3272.4 pounds, is considered when determining the minimum allowable quantity distance. Checking Table 17-11 in AMCR 385-100, the Class 7 distances for inhabited buildings, it is found that for explosive quantities between 3,000 and 4,000 pounds the minimum distance is 635 feet. For the same quantities of explosives Table 17-11 also shows a minimum distance of 380 feet for public highways and railways. A comparison of these values with the ones presented in Figure 4.1 shows no violation will occur for the quantities of explosives calculated.

TABLE 4.4

MAXIMUM EXPLOSIVE QUANTITIES IN ONE SUBMODULE*

CARTRIDGE TYPE	EXPLOSIVES PER ROUND	NUMBER OF ROUNDS PER RUN	NUMBER OF RUNS	MAXIMUM AMOUNT OF EXPLOSIVES AT SUBMODULE
M56A3 HEI	.0906	12,000	3	3261.6
M53 API	.0885	12,000	3	3186.0
M246 HEIT-SD	.0909	12,000	3	3272.4
M242 HEIT	.0900	12,000	3	3240.0

* All explosive quantities are listed in pounds

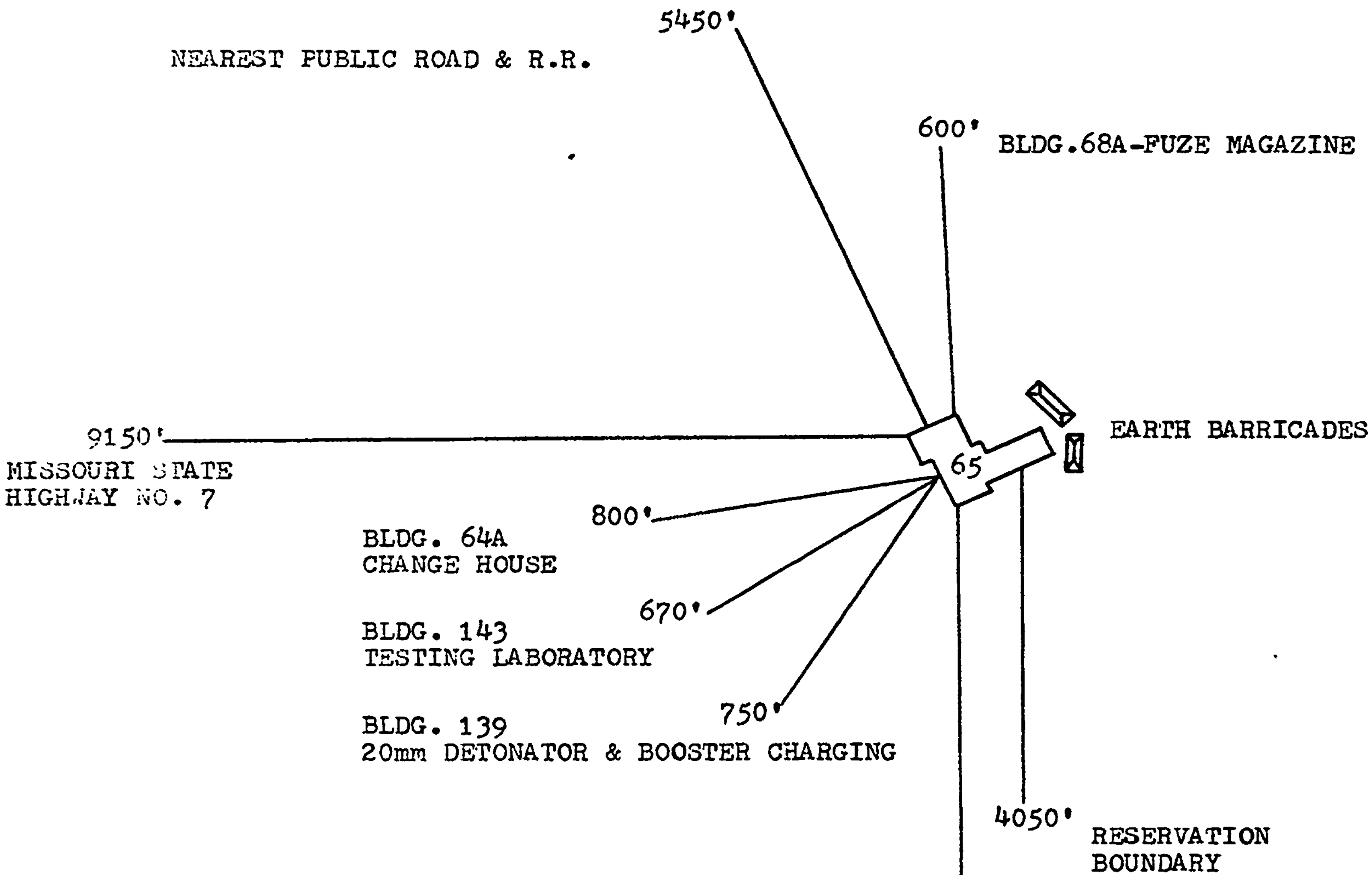


FIGURE 4.1

STRAIGHT LINE DISTANCES FOR BUILDING 65

It should be noted that only the Load and Assemble and Packing submodules will have completed rounds in them. Therefore the other submodules within the building will not have the maximum amounts of explosives present as listed in Table 4.4 . This provides for yet another margin of safety.

When ammunition is packed and ready for shipment it is considered Class 2 and therefore larger amounts af ammunition could be allowed to accumulate at the end of the packaging submodule. In fact, for the quantity distances present around Building 65 up to 500,000 pounds of Class 2 explosives may be present according to Table 17-5 in AMCR 385-100 . While it is permissible for large quantities of Class 2 explosives to accumulate it is recommended that actual quantities be held to as low a level as possible by use of an effective trucking schedule which would remove completed rounds and transfer them to the appropriate storage facilities.

ANALYSIS OF SPACE REQUIREMENTS

Building 65 is presently being used for production of small caliber ammunition. The building therefore already has a number of bays in the present loading wing. These will be used for containment of the submodule equipment for all but the packaging operations.

The overall dimensions of Building 65 are given on a plan view drawing, Figure 4.2 . The gross envelop dimensions and the required square footage for each submodule is given

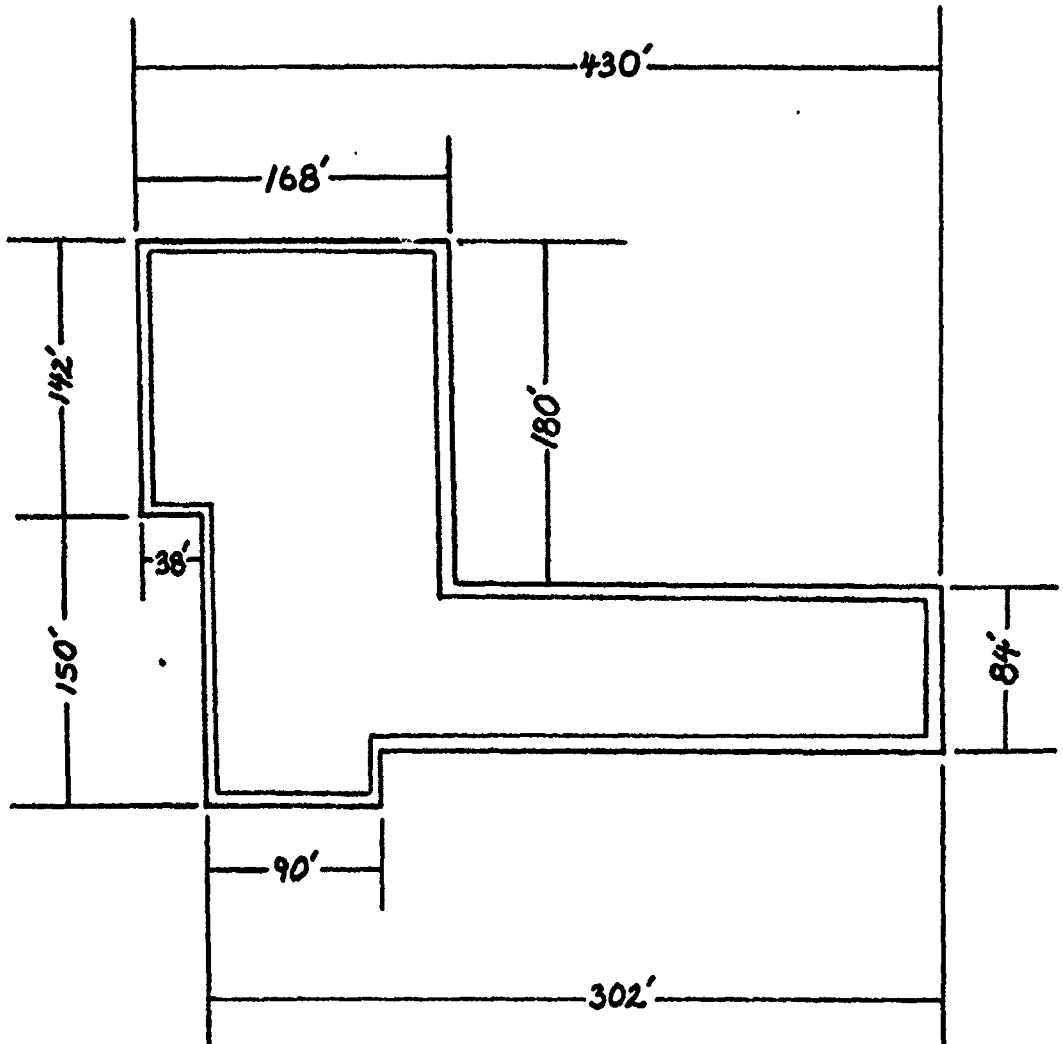


FIGURE 4.2

PLAN VIEW OF BUILDING 65

* All dimensions drawn to the nearest foot

TABLE 4.5

SPACE REQUIREMENTS FOR SUBMODULES (MACHINES ONLY)

SUBMODULE	GROSS ENVELOP DIMENSIONS	FLOOR SPACE (ft^2)
	W X L X H	
HE/HEI CHARGING	8'X28'X10'	224
LOAD & ASSEMBLE	9'X25'X8' (Assemble)	315
	9'X10'X6' (Inspect)	
TRACER CHARGING	14'X30'X10'	420
FUZE-TO-PROJ. ASSY.	7'X16'X8' (Assemble)	182
	7'X10'X8' (Inspect)	
LINK PACKING	30'X70'X10' *	2100

* Does not include palletizing and manual rework area

in Table 4.5 . This is the area necessary for the machinery only and was obtained from data found in the *System Integration Report for Preparation/Layout Planning for Module B*, dated July 15, 1975.

In addition to the square footage needed in each submodule for the machinery, areas must be available for storage of inert and hazardous materials and components. There must also be space provided for storage of spare parts for quick repair, for example quick change tool sets. This space should be large enough to accomodate quantities of material that would be received by trailer trucks in normal truckloads. Sufficient aisle space should also be provided for efficient material handling. It is recommended that 20 ft^2 or 10 per cent of the submodule area, whichever larger, be allowed for submodule supplies and 40 ft^2 or 25 per cent of the submodule area, whichever larger, be allowed for spare tooling and presetting fixtures. Table 4.6 shows the adjusted areas necessary to meet the requirements.

Operator stations will be designed in such a manner as to maximize safety for all personnel and to remain compatible with the system. The stations will provide noise attenuation, vibration isolation and complete environmental control, temperature, humidity, etc. Double panelled glass walls have been suggested as a possible means perator supervision for respective submodules. Howeve for improved safety it is recommended that the operator stations be equipped with closed circuit television monitoring which

would enable them to be completely barricaded form all explosive hazards during operation, a method similar to that described in Chapter 2 of this report.

The existing configuration of Building 65 lends itself ideally to the incorporation of two production lines. It is recommended that the entire loading wing be used to spread out the charge and assembly operations. This can be accomplished by utilizing the existing 30 bays within the wing. Each bay has identical dimensions, 19 feet by 34 feet, or 646 square feet of useable floor space. Refering to Table 4.6, Submodule Space Requirements, it can be seen that each of the four submodules to be located in the wing will easily fit within the existing bays. This is due to the fact that all required areas are below the 646 square feet available. It is also recommended that the submodules be separated by empty bays,when possible.

Two production lines will be operated parallel to each other seperated by a 13 foot wide corridor. The bays in each production line containing hazardous materials and operations should be opposite empty bays or bays containing inert storage. This will minimize the chances of explosive propagation in the event of an accident.

Mr. Paul R. Zirkel in his Facility Systems Analysis of Module B has suggested a layout which incorporates all of the above mentioned design criteria. Figure 4.3 indicates the proposed usage of existing bays. The labeled areas on the plan view drawings are meant to show suggested locations

TABLE 4.6

SUBMODULE SPACE REQUIREMENTS

ADJUSTED FOR SUPPLIES AND MATERIAL HANDLING

SUBMODULE	MACHINE REQUIREMENT (ft^2)	TOTAL REQUIREMENT (ft^2)
HE/HEI CHARGING	224	302.4
LOAD & ASSEMBLE	315	425.25
TRACER CHARGING	420	576
FUZE-TO-PROJ. ASSY.	182	245.7
LINK PACKING *	2100	2835

* Does not include palletizing and manual rework area

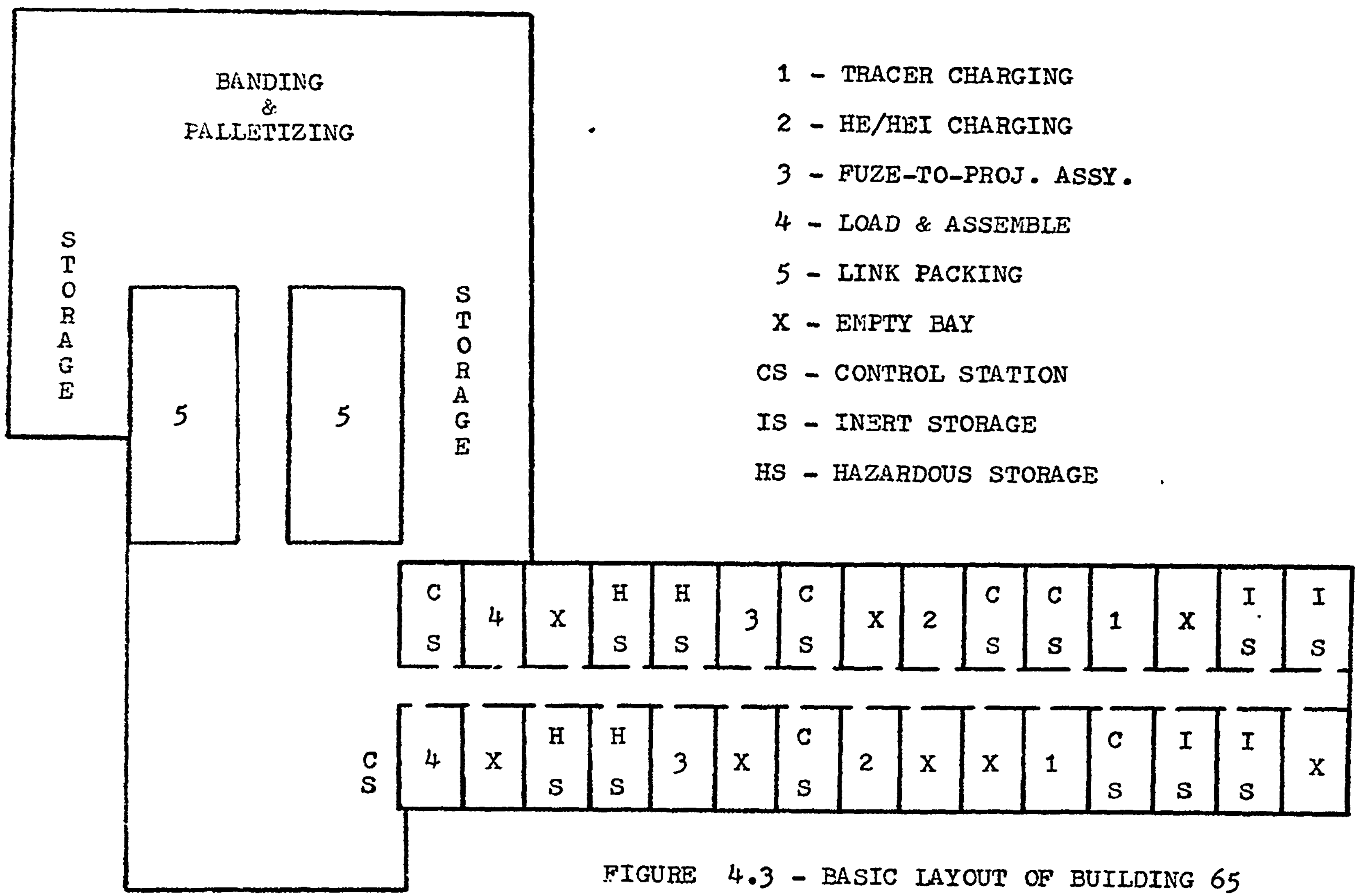


FIGURE 4.3 - BASIC LAYOUT OF BUILDING 65

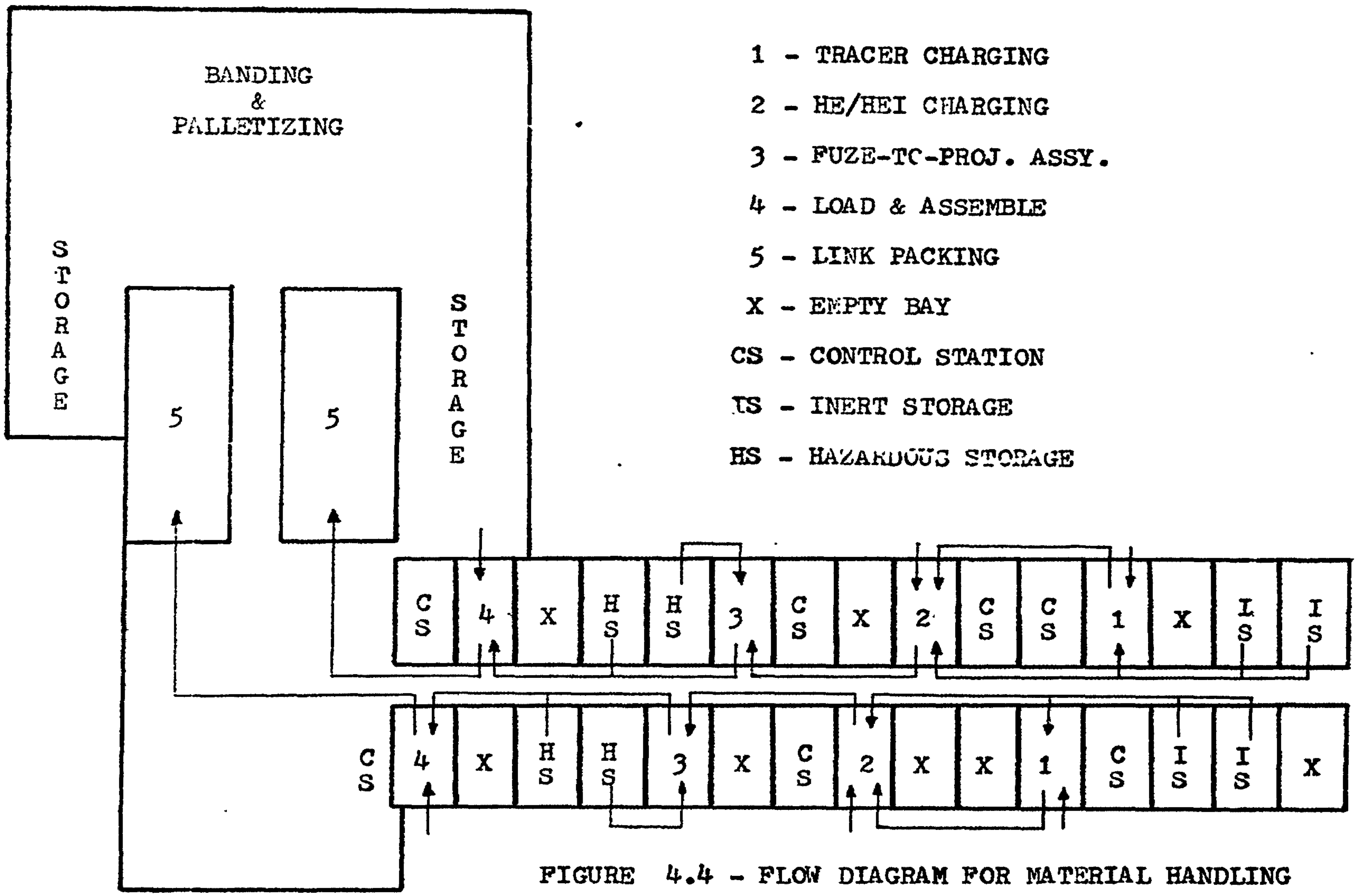


FIGURE 4.4 - FLOW DIAGRAM FOR MATERIAL HANDLING

of submodules and associated areas only, and are not intended to represent the actual final dimensions. Figure 4.4 indicates the material flow between submodules. This diagram is intended to show sequence of flow and not necessarily the exact path the material will take.

ADDITIONAL CONSIDERATIONS CONCERNING REDESIGN

One major proposal in the redesign of Building 65 is an addition to be constructed as shown in Figures 4.5 and 4.6 . It is recommended that the reasons for construction of this new addition be carefully considered. Analysis has shown that there is sufficient space within the existing structure to completely incorporate the submodules necessary for the operation of the two proposed production lines.

If the shipping dock were located at the end of the packaging line, along the west wall of the building, the ammunition would finish production at the site of shipment. This would eliminate the need for moving the ammunition back past the packing equipment to the proposed new addition for shipment.

The proposed equipment room in the lower level could be located on the roof of the building. All major airconditioning and heating companies have a wide selection of roof-top package units or custom equipment could be designed to fill specific needs.

It is a fundamental rule of safety that when possible, personnel should be removed from the area of the hazard.

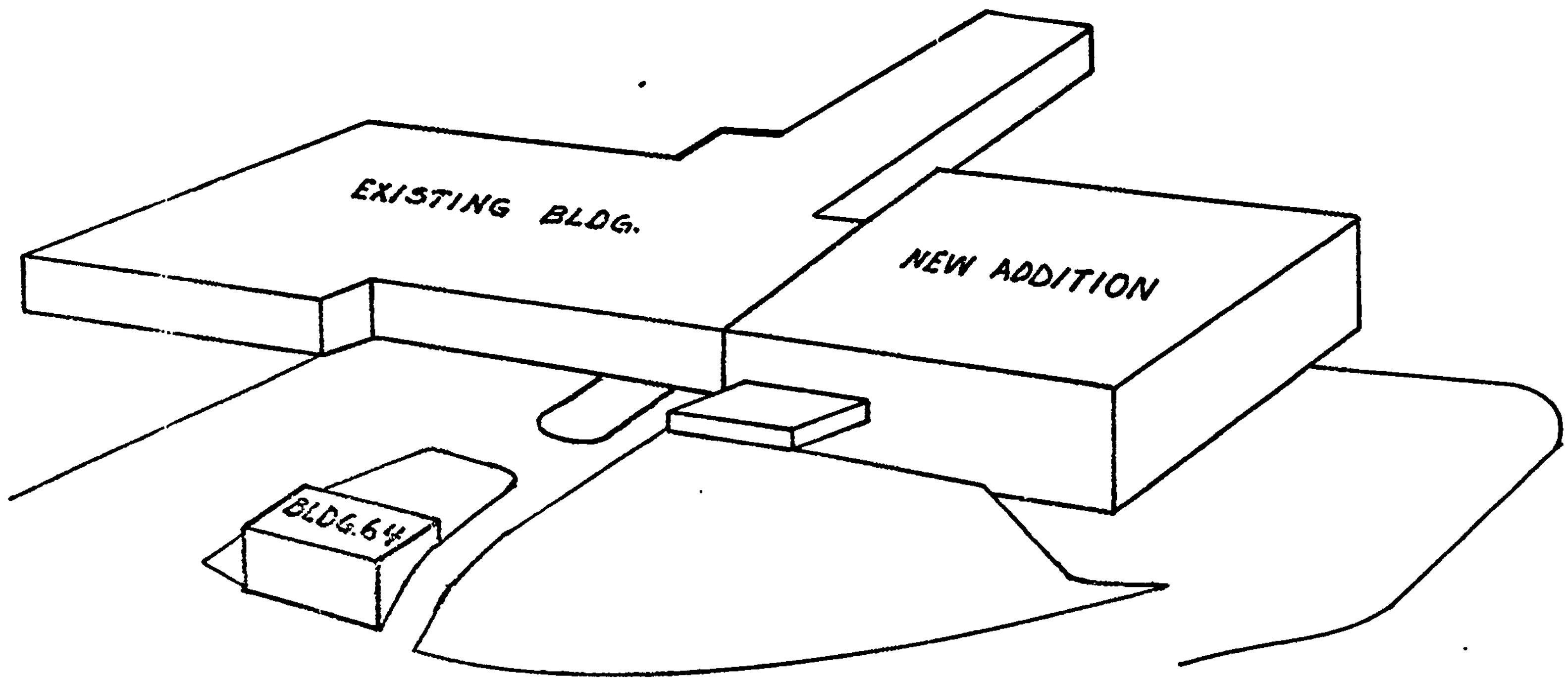
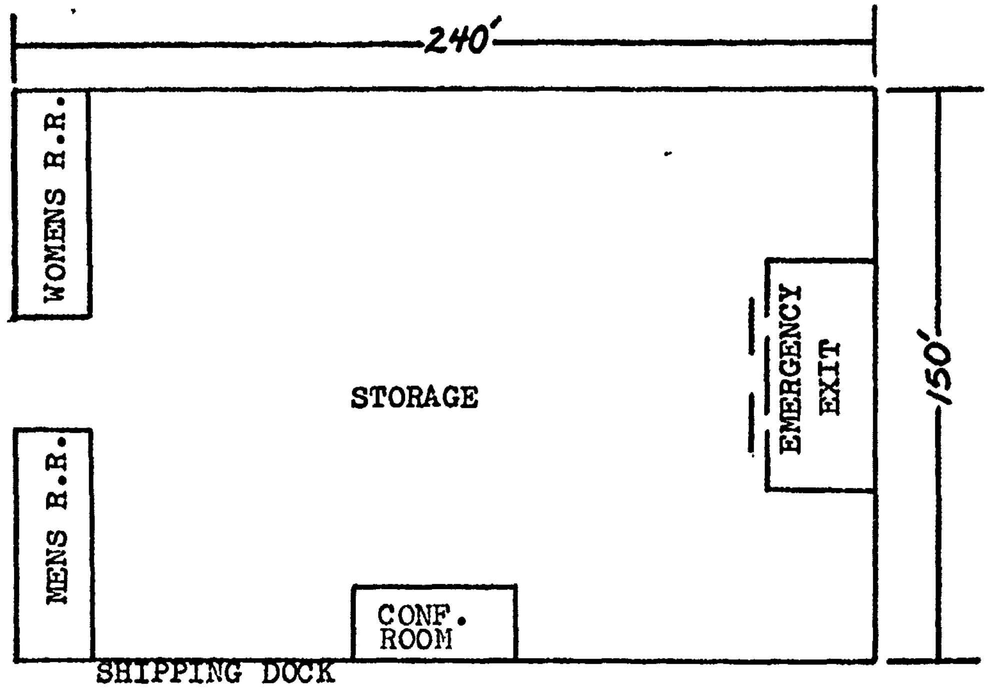
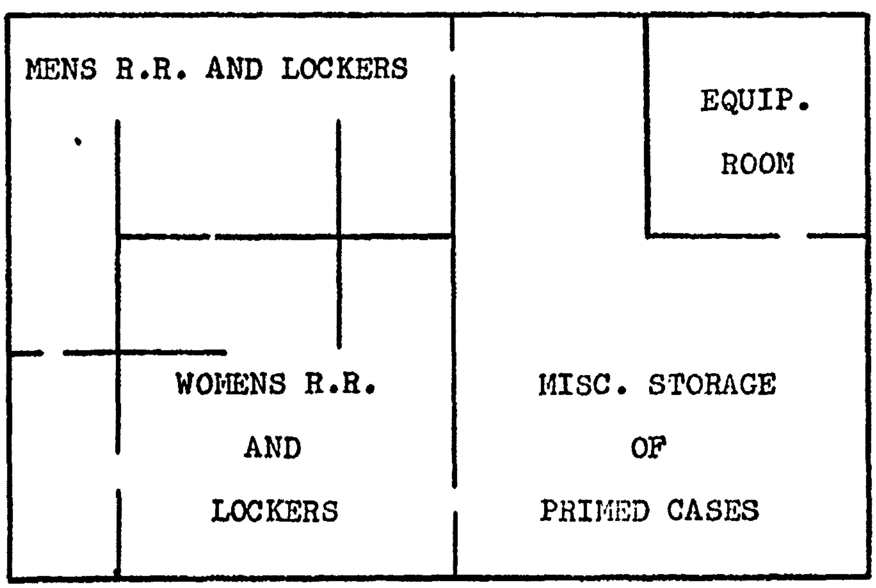


FIGURE 4.5

BUILDING 65 WITH PROPOSED ADDITION



GROUND FLOOR



LOWER FLOOR

FIGURE 4.6

FLOOR PLANS OF PROPOSED ADDITION
TO BUILDING 65

Therefore it is felt that by building locker facilities for employees within the explosives facility, it would cause them to remain in the area for longer periods of time than necessary. As the new SCAMP system will need fewer employees to run the facility due to automation, it is recommended that the current locker facilities away from the building continue to be used.

Among the proposals made in Mr. Zirkel's report is the placement of the quality control computer equipment in Building 65. It is felt that since all monitoring information relayed to the computer is by electrical impulse, there is no reason for placing this extremely expensive equipment in an explosives facility and exposing it to that hazard. With the use of simple direct line telephone communication the computer operator can relay any information necessary to the proper personnel on location.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The basis for this report was to determine whether or not Building 65 would be suitable for use as a production facility for SCAMP B. It is felt that the analysis contained herein has shown that the building would serve as an excellent site. It is also felt that the two proposed production lines could be located within the existing structure and that any additional construction would be supplemental to the basic needs for production. The existing loading wing, with its 30 bays, is especially convenient in that the submodules to be housed will fit within the bays, making extensive renovation unnecessary. The parallel production lines suggested will enable material to flow uncongested throughout the facility.

The quantity distances surrounding Building 65 are sufficiently large, causing no problem with the explosive quantities that will be present for the initial method of production. However, it is recommended that additional analysis be conducted to determine the allowable quantities of explosives for the conveyer type transfer system which will inevitably be used.

When the automated transfer system is in operation the quantities of explosives present will most likely increase greatly. The quantity distances unfortunately are fixed

and limit the amount of explosives allowed within the building unless massive barricades are constructed. Here would be an ideal opportunity to apply the use of the new concept of suppressive shielding. The objective being decreased barricading costs and a greater margin of safety allowing for the use of the required amounts of explosives. The author therefore recommends this as an area of possible research.

The renovation of this country's methods of producing ammunition was definitely long overdue, and this author feels that the SCAMP system will be an effective method of resolving the present problem. The system is sound in principle and once operating as designed will far surpass the antiquated production methods now being used.

BIBLIOGRAPHY

1. Accident Prevention Manual for Industrial Operations, 6th ed., Chicago, Ill., National Safety Council, 1973.

2. Apple, James M., Plant Layout and Materials Handling, 2nd ed., New York: Ronald Press Company, 1963.

3. Dobbs, Norval, Approved Safety Concepts for Use In Modernization of USAMUCOM Installations, Safety Engineering In Support of Ammunition Plants, 1972.

4. Department of Defense Military Standard, System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for, Military Standard 882, 1969.

5. Department of Defense, Ammunition and Explosives Safety Standards, DOD 4145.

6. Hammer, Willie, Handbook of System and Product Safety, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

7. Handbook of Industrial Loss Prevention, 2nd ed., New York, Factory Mutual Engineering Corp., 1967.

8. Johnston, W. L., Street, R. L., Preliminary Hazard Analysis for Load-and-Assemble Submodule, Module A, SCAMP, November 1972.

9. Kemp, Herman O., "A Proposed System Safety Program Plan for Module 'B' Small Caliber Ammunition Modernization Program," Research Report, Texas A&M University, May 1973.

10. Modahl, Craig A., "System Safety Engineering Analysis of Two Plant Layouts for Small Caliber Ammunition Modernization Program Module 'B'," Research Report, Texas A&M University, April 1975.

11. Rodgers, William P., Introduction to System Safety Engineering, New York: John Wiley and Sons, Inc., 1971.

12. Technical Report 4429, Approved Safety Concepts for Use in Modernization of USAMVCOM Installations, Manufacturing Technology Directorate, 1972.

13. Thompson, Robert G., "A System Anaylsis of a Proposed Building for Module 'B' SCAMP," Research Report, Texas A&M University, March 1973.

14. U.S. Army Small Caliber Ammunition Modernization Program Document, Briefing to Major General George Sammett, Jr., Deputy Chief Reasearch and Development, October 1971.

15. U.S. Army Ammunition Production Base Restructure Study, Small Caliber Ammunition Modernization Program, SCAMP, for the Manufacture of Standard 20mm Ammunition, Manufacturing Technology Directorate, 1973, 1974.

16. U.S. Army, System Integration Report for Preparation/ Layout Planning for 20mm Ammunition, Module B, Frankford Arsenal, Philadelphia, Pa., June 1975.

17. U.S. Army Materiel Command Regulation AMCR 385-100, 1973.

18. U.S. Army Materiel Command, Munitions Production Base Modernization and Expansion Plan, January 1975.

19. U.S. Army Technical Manual, Structures to Resist the Effects of Accidental Explosions, TM 5-1300, June 1969.

20. U.S. Army Materiel Command Pamphlet, System Safety Management, AMCP 385-23, 1969.

21. U.S. Army, Safety for Systems, Associated Subsystems and Equipment, AR 385-16.

22. U.S. Army Materiel Command, Determination of Ammunition and Explosive Characteristics that Influence Handling, Storage and Transportation Criteria, AMCR 385-21.

23. Zirkel, Paul R., Preliminary Technical Report, Facility Systems Analysis - Module B for Lake City Army Ammunition Plant, Volume II, Part I, Honeywell, Inc., 1973.

24. Zirkel, Paul R., Preliminary Technical Report, Facility Systems Analysis -Module B for Lake City Army Ammunition Plant, Volume II, Part II, Honeywell, Inc., 1973.

25. Zirkel, Paul R., Final Technical Report, Facility Systems Analysis - Module B for Lake City Army Ammunition Plant, Volume I, Methodology and Results, Honeywell, Inc., November 1973.

26. Zirkel, Paul R., Final Technical Report, Facility Systems Analysis - Module B for Lake City Army Ammunition Plant, Volume II, Appendixes, Honeywell, Inc., November 1973.